WHOI-99-03

Woods Hole Oceanographic Institution

R/V Seward Johnson Cruise Report (SJ-9807) ACCE S-PALACE Float Deployments

By

Ellyn T. Montgomery
Brian J. Guest

February 24, 1999

Technical Report

Funding was provided by the National Science Foundation under Grant No. OCE-831869

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Terrence M. Joyce

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Abstract :

R/V Seward Johnson cruise 98–07 occured between October 12 and November 5, 1998. The goal of the cruise was to deploy 30 **S**alinity **P**rofiling **A**utonomous **LA**grangian **C**urrent **E**xplorer (**S–PALACE**) floats in the tropical Atlantic as part of the **A**tlantic **C**irculation and **C**limate **E**xperiment (**ACCE**). These floats are neutrally buoyant and drift with the water in which they are deployed. They are programmed to obtain temperature and salinity profiles of the top 1000 meters of the ocean every ten days. To ascertain the validity of the float data, a CTD profile was made at the site and time of the deployment of each float.

The data from these floats augments data already being obtained from ten floats deployed in July of 1997. Given 40 floats in the tropical North Atlantic, reporting every 10 or 14 days with an expected operational life of 3–5 years, we hope to gather 5000 to 7000 temperature and conductivity profiles in the coming years. The temperature and salinity profiles, along with derived properties will aid in examining the mechanisms of upper ocean heat and freshwater storage. This data, combined with satellite sea surface data should provide useful input to climate and weather prediction models.

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Introduction :

The Atlantic Circulation and Climate Experiment (ACCE) is a large multi–investigator program designed to observe, quantify and describe the Meridional Overturning Circulation (MOC) within the North Atlantic Ocean. To accomplish this objective, oceanographers proposed to investigate many components of the circulation, using a variety of methods: CTD/ADCP sections with associated chemical tracer studies, moored timeseries measurements, Lagrangian observations, and modeling studies. The ACCE proposal was funded by the National Science Foundation and research was started in 1996.

Upper layer processes in the tropics and associated water mass transformations are important for understanding how the MOC works. Autonomous LAgrangian Current Explorer (ALACE) floats are appropriate instruments for obtaining the measurements that quantify these processes. Once the floats are deployed, they work unattended. They collect and telemeter profiles of conductivity and temperature to land–based receiving stations at pre–programmed intervals. After transmitting data at the surface, each float descends to its ballast depth and drifts with that water mass. At the completion of its programmed drifting interval, the float ascends to transmit its next profile. These floats are capable of providing data from wherever they are for over two years from the date of deployment.

The ACCE proposal calls for ALACE floats to be deployed at nominal 5–degree intervals in the equatorial to subtropical Atlantic, with denser spacing in the area of 18 degree water formation (26N–38N, 48W–76W). This report documents the deployment of 30 floats along 11N and 16N in October 1998, as part of the overall ACCE science program. These floats were deployed to complement the measurements already being made by the ten floats deployed along 6N on a cruise in July, 1997 (M.Baringer, NOAA/AOML, Chief Scientist). The profiles of temperature and salinity collected by these floats will be made available to investigators studying the ocean's link to climate in the tropical and subtropical regions of the North Atlantic. The main purpose of the floats deployed between 6N and 16N is to investigate the "Upper Ocean Response to Thermohaline Forcing in the Tropical North Atlantic" as outlined in the NSF grant of that name, R.W. Schmitt, Principal Investigator.

Cruise Objectives :

The goals of this cruise on the *R/V Seward Johnson* were to check out and deploy 30 Salinity Profiling Autonomous LAgrangian Current Explorer (S–PALACE) floats along 11N and 16N, and to make high quality hydrographic profiles accompanying the deployment. Accurate Conductivity Temperature and Depth (CTD) profiles are important for verifying the quality of the calibration coefficients of each float. Additional hydrographic profiles were made along the cruise track west of 52W to observe whether thermohaline staircase features first observed during the Caribbean–Sheets And Layers Transect (C–SALT) program

(Schmitt et al., 1987) still exist in the area.

The spacing of the S–PALACE floats at deployment was nominally 5 degrees of latitude and 2 to 5 degrees of longitude. The longitudinal spacing we used was chosen to match where the floats along 6N had been deployed. Additional floats were inserted in the western part of the basin to increase resolution where the circulation patterns are more complex. Six floats were deployed on 13.5N to improve grid resolution. Figure 1 shows the cruise track, with the positions of S–PALACE deployments indicated by diamonds. The CTD stations added near Barbados to look for salt fingering are shown by black triangles. The deployment positions of the floats deployed in 1997are indicated by black dots.

Cruise Participants :

The science party for this cruise was small because there was not enough work to justify bringing a second watch. Station spacing was 11 to 22 hours, so one watch could accomplish all the work, if they kept an irregular schedule The scientists were all from the Woods Hole Oceanographic Institution, and all experienced seafarers for whom one or two stations a day was an easy assignment. The work at each station was divided into three jobs: computer operator; deployment preparation and deck; and water sampling and deck. These jobs were rotated among the three WHOI participants listed below:

Ellyn Montgomery	Chief Scientist
Brian Guest	S–PALACE float & CTD technician
David Wellwood	CTD technician

Additional support was provided by the University of Miami resident technicians assigned to this cruise, Chip Maxwell and Don Cucchiara.

Cruise Narrative :

This cruise was delayed a week by Hurricane Georges' transit through Florida prior to the *R/V Seward Johnson's* departure from Ft. Pierce. The ship left port late, so all subsequent cruise legs were moved back equally. We met the ship in Barbados and started setting up and testing our equipment on October 11. The work in port went smoothly, and by the time the ship departed Bridgetown on October 12, 1998 at 1400, all hands were ready to be underway. The indentifier code for this cruise is SJ9807. The conditions at departure were cloudy with 15 kt. winds and slight swells.

In order to evaluate whether the thermohaline staircases observed in 1985 during the C–SALT program were still present, five CTD casts to 2000 meters depth were planned en route to the first S–PALACE deployment position. The stations were evenly spaced at

Track of 1998 S-PALACE deployment Cruise

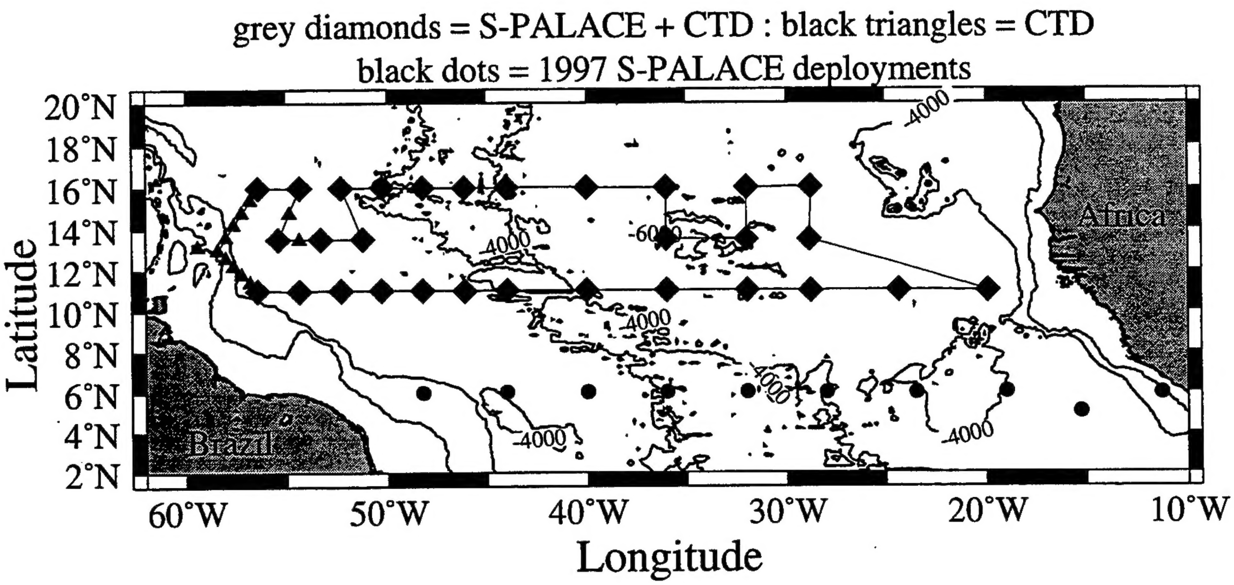

Figure 1. Chart showing the track of the 1998 deployment cruise. The S–PALACE floats deployed on this cruise are shown as diamonds and those deployed in 1997 are shown as dots. CTD profiles made on this cruise where floats were not deployed are indicated by small triangles.

approximately 40–nm intervals along the line between 13 30'N, 58 48'W and 11 0'N, 56 24'W. Clearance to work inside Barbados' territorial waters was received on September 2, 1998 in the approval letter from the U.S. Department of State, number 98–027.

A six hour steam along the south coast of the island was required to reach the first of these hydrographic stations: we arrived on site at 2016h. After the CTD was deployed, we observed that the CTD conductivities were not on scale of the display. The deck unit reported reasonable counts, suggesting a correctable calibration problem, so the profile was continued. The water depth here was shallow enough to warrant using the pinger for finding the bottom. All the other stations were in deep enough water that the 2000 db profile termination criterion was reached long before the CTD was near the bottom. When the CTD was back on deck, we found that during assembly and configuration of the CTD in port, the primary and secondary sets of sensors had been connected to the opposite sets of endcap penetrators, so the calibration file used for the first cast was incorrect. Re–processing the raw data with a modified calibration file produced reasonable values. The primary and secondary sets of sensors were connected to the correct plugs before cast two. The original calibration file worked fine on dive two and subsequent stations. Hydrographic stations one through five were occupied as we headed southeast during October 12 and 13. Strong evidence of thermohaline staircases was found in cast 4, and the others only showed signs of weak features.

Each float has two IDs associated with it, the three digit serial number, and the five digit code for the internal transmitter. In this group's tracking system, the serial number is used for reference until deployment, then the PTT ID is used after the data is transmitted through the satellite. The PTT ID corresponding to each serial number is listed in the station log presented in Appendix 1. Since the first 40 hours of the cruise was expected to be very busy with the closely spaced CTD stations, we prepared the first two S–PALACE floats before we left port. The floats were unpacked, brought into the lab, the delrin collars were attached, and the floats secured in their cradles for transit. About five hours before the first deployment was planned, the startup test of the first float, number 240–PTT ID 29642, were commenced. After passing the magnet over the switch, the transmitter beeped, the motors were heard turning, and the bladder started to fill, indicating a succesful startup sequence.

The ship arrived at station 6 for the first S–PALACE deployment on October 14 at 0013h. A CTD cast to 2000 meters was made. Once the CTD was back on deck, S–PALACE float 240 was deployed, then the ship commenced steaming to the next station. A chart of the CTD stations occupied and the PTT numbers of the floats deployed is shown in figure 2. Each float was deployed at the position where the CTD cast was completed. No attempts were made to steam the short distance back to the target station position. A CTD cast followed by a S–PALACE float deployment and a transit became the normal routine of the cruise. The station spacing in the western basin was about 120 nm, so about 11 hours transit time was expected between stations.

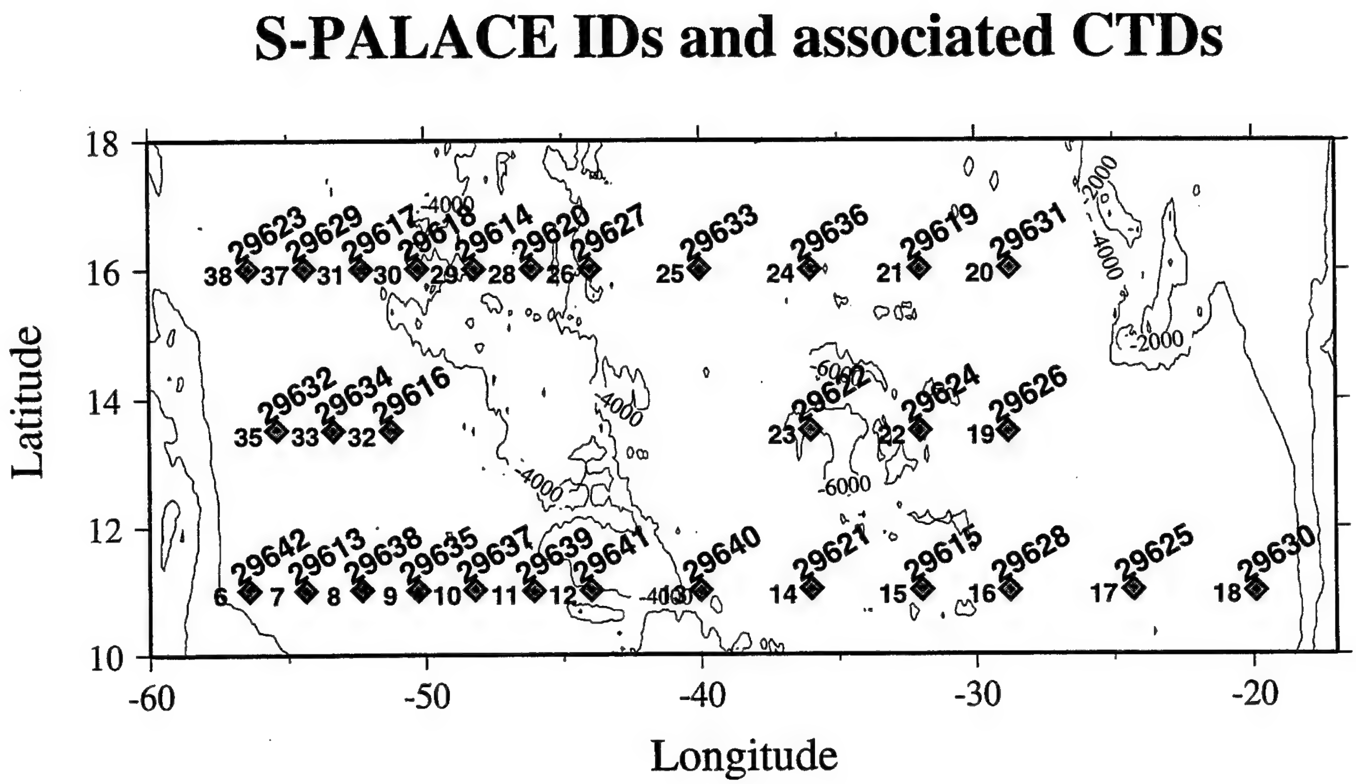

Figure 2. Chart of the research area with the PTT ID numbers and CTD station numbers annotated.

Stations 7 and 8 went smoothly, in reasonable weather. The CTD data showed strong thermohaline staircase features at these two stations in the depth range of 200 to 500 meters. We arrived at station 9 at 1346 on October 15, in worsening weather. After station 9, the weather deteriorated, so the transit took longer than normal. We did not arrive on station to start CTD 10 until 0400h on October 16. The transit between stations 10 and 11 was also longer than expected due to weather. A series of tropical waves progressed westward along 11 N, as we moved eastward. One of these tropical waves developed into Hurricane Mitch, which wreaked havoc in some Gulf coast regions of Central America.

The spacing of the stations increased to about 240 nm after station 12, giving almost a day between stations. Station 12 was west of the Mid–Atlantic Ridge and station 13 was slightly east of the crest. Float 235 was supposed to be deployed at station 15, but failed its pre–deployment self–test. Float 214 was prepared instead, and deployed after CTD cast 15. Brian started to debug the bad float by doing some diagnostics and emailing some questions back to WHOI. The weather continued to be periodically stormy through October 21 after station 16. The weather improved for the easternmost part of our track, making deployment and recovery of the CTD package more pleasant. The line was completed uneventfully with CTD cast 18, and the deployment of float 229, on October 23.

To review, the 11N leg of this cruise was made eastbound and was consisted of CTD stations 6–18. The S–PALACE floats deployed along this line are, from west to east: 240, 200, 222, 234, 213, 236, 239, 238, 220, 214, 237, 225, and 229 (by PTT ID: 29642, 29613, 29638, 29635, 29637, 29629, 29641, 29640, 29621, 29615, 29628, 29630). These stations were completed between October 14 and 23, 1998. The easternmost station at each latitude (18, 19, 20) was situated to assure it would be outside African and Cape Verdian territorial limits. A 48–hour steam was required to get from station 18 to station 19.

Due to the currents and prevailing winds, all the excursions to 13.5 degrees were made from the 16N line. This allowed for optimization of the ship's speed and comfort of the ride. The first five stations on the eastbound leg alternated between 13.5N and 16N. CTD stations 19–24 were occupied between October 25 and 28. The S–PALACE floats deployed following these stations were 226, 230, 218, 224, 221, and 235 (by PTT ID: 29626, 29631, 29619, 29624, 29622, 29636) respectively. The problem with float 235 was determined after several days, and was successfully fixed and tested, so it was deployed.

On October 28, we started to work across the middle part of the 16N line. This began several days on a westerly course, which, given the prevailing winds and currents, provided a comfortable ride. This also allowed us to make up some of the time lost to rough weather coming east on 11N. CTD cast 25 followed by the deployment of float 232 occurred October 29 between 1220 and 1400. CTD 26 and the deployment of float 227 happened 20 hours later.

Two PALACE floats were deployed for Peter Vertes of U. Miami on this cruise. Station 27 was added at his request for deployment of his float #174. The CTD cast and float deployment occurred on October 30. CTD stations 28 and 29 with the deployments of WHOI floats 214 and 212 were completed between October 30 and 31. The other U.Miami float (#195) was deployed with our float 217 following cast 30 on October 31. Several mysterious shipboard sightings occurred on October 31– Moses, a werewolf and a wicked witch all made appearances, but were never seen again.

The progress along 16N continued with CTD cast 31, occupied on November 1. S–PALACE float 216 was deployed following this cast. The cruise track diverted back to 13.5N for the next four stations. These spanned the longitude range of 51 13.2'W to 55 22.75'W. Station 32 was the easternmost, and was commenced at 0052 on November 2, with S–PALACE float #216 deployed after the CTD was completed. A 10 hour transit westward preceded station 33, where float #233 was deployed after the CTD. Station 34 was CTD only and was added midway between the original station positions, in hopes of finding more evidence of salt fingering. This station was reached after only 5 hours, and showed no evidence of thermohaline staircases. The last station on 13.5N was 35, where the CTD was completed then float 231 was deployed. This profile showed evidence of intrusions and inversions between 200 and 800 decibars, but no true staircase features. Another CTD–only station, cast 36, was added midway between 35 and 37, on the way back to 16N. This profile had some staircases between 400 and 600 meters.

We arrived back on 16N at 54 21'W on November 3 at 1400. CTD cast 37 was followed by the deployment of float 228. Another 10–hour transit brought us to the site of the final S–PALACE deployment. The CTD cast there was commenced at 0632 on November 4. The last float of the cruise, 223, was deployed immediately following CTD cast 38.

To review, the 16 N leg was made westbound, and included excursions to 13.5N. This part of the cruise was accomplished between October 25 and November 4 . The CTD stations made during this part of the trip were 19 – 38. The float deployment longitudes matched those for the floats deployed on 11N, where there was no interference with territorial waters. From west to east (reverse deployment order), the floats deployed on 16N are: 223, 228, 216, 217, 212, 219, 227, 232, 235, 218, 230 (by PTT ID: 29623, 29629, 29617, 29618, 29614, 29620, 29627, 29633, 29636, 29619, 29631). Along 13.5 N, three floats were deployed at the east and west sides of the basin. From west to east, they are : 231, 234, 216, 221, 224, 226 (by PTT ID: 29632, 29634, 29616, 29622, 29624, 29626).

The final work of the cruise was five more CTD stations evenly spaced along the line back to the site of the first CTD. Stations 39 – 43 progressed smoothly at 4.5 hour intervals between November 4 at 1139 and November 5 at 0440. The profiles from these stations hinted at instability and mixing in the depth range between 400 and 800 meters, but no well–defined

thermohaline staricases were observed. To obtain an estimate of the temporal variability in the area, cast 43 occupied the same site as cast 1, 24 days later. After the CTD was brought on deck after cast 43, the transit back to Barbados was commenced. The *R/V Seward Johnson* arrived at the dock in Bridgetown at 1050 November 5, 1998.

Data Acquisition systems :

Underway measurements :

Several kinds of measurements were made while the ship was underway during this cruise. Continuous downward–looking ADCP data was acquired from the ship–mounted RDI 150 KHz narrowband system at 5–minute intervals. The *R/V Seward Johnson* uses an integrated shipboard data logging system called CIDS which integrates and stores data frommost of the ship's sensors. The parameters logged by this system were acquired at 1–minute intervals, and include: positions from the navigation system, atmospheric data from the IMET system, sea surface temperature and salinity from the thermosalinograph, and water depth from the Datasonics Chirp system. In periods of rough weather, the echo returns from the Chirp were overwhelmed by noise and bubbles from breaking waves at the surface, so the transponder was turned off. Whenever the weather was favorable the system acquired data that was logged by CIDS.

Hydrography :

A Seabird Instruments 911+ CTD instrumented with redundant pumped temperature and conductivity sensors was used for this experiment. No oxygen measurements were taken. The CTD, sensors, 24–4 liter bottles, and the frame were supplied by WHOI. The cassette controlling bottle firing, deck unit, power supply and data acquisition PC were supplied by Harbor Branch Oceanographic Institution (HBOI). The sensors were calibrated at WHOI before the cruise, and the system was assembled and tested in Barbados prior to sailing. The sensors were also sent back to Seabird for a post–cruise calibration. This proceedure was employed to assure that the best calibration coefficients were used, and to verify the good agreement between the two sensor pairs

The primary sensors were mounted on the CTD, towards the center of the package, the secondary pair was mounted on the outer side of the CTD, nearer the frame. Both sets of sensors were mounted 4 inches from the bottom of the rosette frame. The primary temperature sensor was #1080, the primary conductivity sensor was #763. The secondary temperature sensor was #1085, the secondary conductivity sensor was #224. The sensors worked well throughout the cruise, and no modifications to the original arrangement were needed. A picture of the bottom part of the package showing the CTD's position in the frame is shown in figure 3.

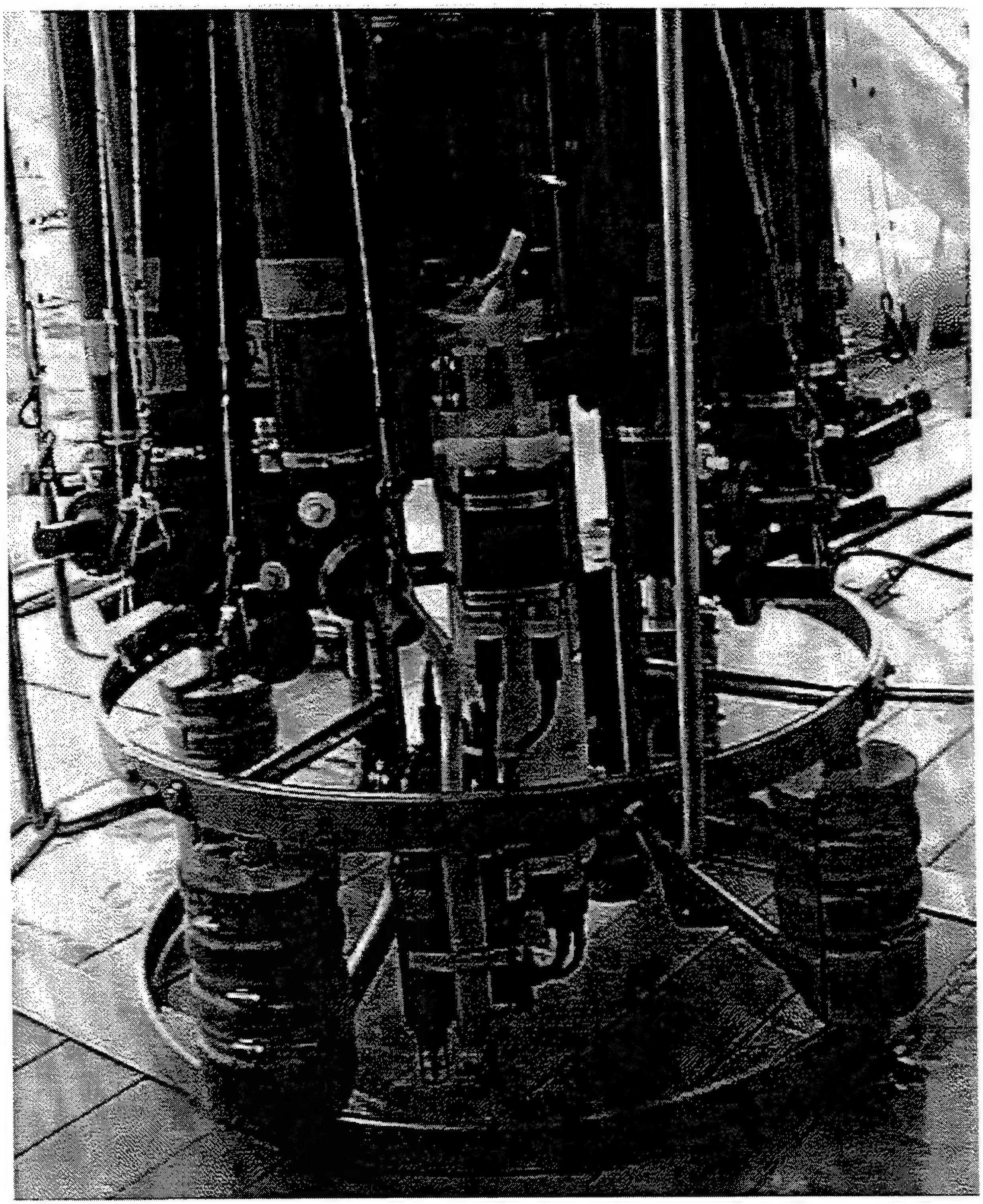

Figure 3. Photo showing the CTD and sensors as mounted in the frame during SJ9807.

The termination was made by the shipboard technicians for the previous leg. It was of the WHOI style, potted "Ceroben" and a stainless steel fitting. Fewer than 50 casts were done on the previous leg and the termination appeared to be in good condition, so the cruise started with the existing termination. A Chinese finger was added just above the termination as a precautionary measure and attached to the frame by a 2 ft. long shot of 3/16" wire rope with swage fittings on each end. Only one conductor within the cable was used and the wire and termination performed well throughout the entire cruise, so the cable never needed to be re–terminated.

Each cast was started by lowering the package at 30 meters/min for the first 100 meters and then increasing the speed to 60 meters/min for the rest of the profile. Casts were stopped when the CTD pressure reached 2000 db. Water samples were taken at 200–meter intervals from 2000 meters to 200 meters, then at depths of 100 and 10 meters. At each depth, two bottles were tripped, though on most casts only one of each pair was sampled. The bottle salinities were all run by Don Cucciara, using the University of Miami autosalinometerss.

The 4–liter Niskin bottles performed well. During the first cast, bottle 14 had a large leak but was repaired by replacing the lower end cap O–ring. Toward the end of the cruise, four different bottles broke lanyards just prior to deployment but were easily repaired. One of the bottles was missing the stainless steel pin at the petcock. There were no spares in the kit so Dave fashioned a pin out of wood that worked for the entire cruise.

After each cast, the package was rinsed with fresh water, and stored in the shade of a canopy to protect the sensors and maintain a reasonable internal temperature. The conductivity and temperature sensors were soaked in distilled water during the transits, and periodically rinsed with dilute Triton–X solution to enhance wetting.

S–PALACE floats :

ALACE floats were developed by Russ Davis at Scripps and Doug Webb of Webb Research (Davis et al., 1992), and they have been used in oceanographic research for more than 5 years. These floats collect and transmit profiles of temperature and/or conductivity autonomously after deployment, for the duration of the battery. After an interval at the surface transmitting data to satellites, the float sinks to the depth for which it was ballasted, and drifts with that water for a pre–programmed time interval, usually one to two weeks. Then the float ascends to the surface and transmits the data acquired on the last cycle. The conductivity and temperature profiles may be obtained on the descent or the ascent, depending on how the float is programmed. A schematic of one of these floats is shown in figure 4.

The WHOI float group assembles parts from Webb Research Co. (housings and most of the mechanicals) and Falmouth Scientific (conductivity sensors), then completes the instrument

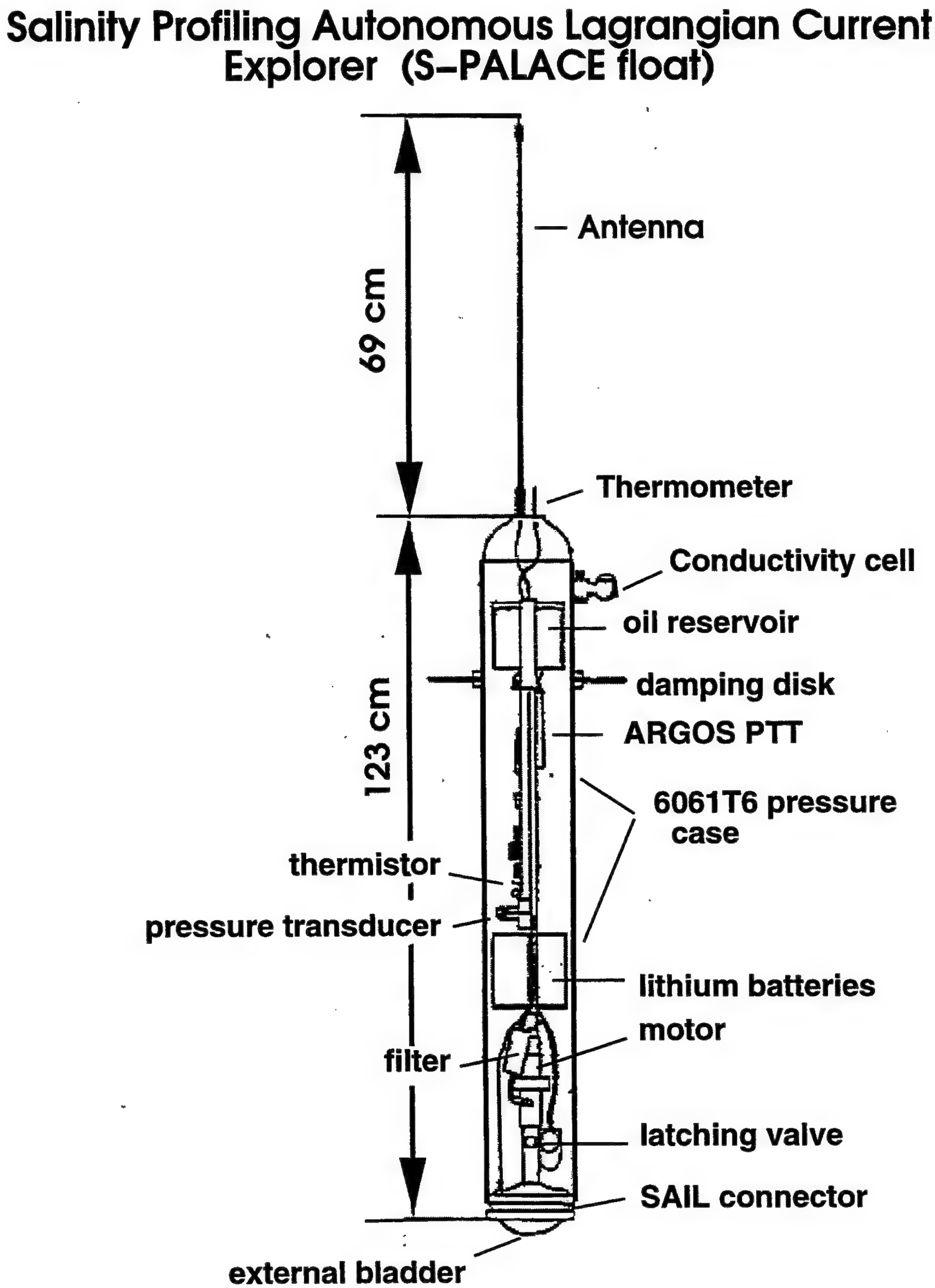

Figure 4. Schematic of an S–PALACE float.

by adding a controller, an ARGOS transmitter, and program ROMs. The floats are tested and ballasted at WHOI before shipping. Just a few days prior to the shipment for this cruise, the source of a calibration offset that had been observed for about a year was discovered. Great efforts on the part of the float group and several FSI employees made it possible to correct this error, test it and adjust the calibrations before the floats were shipped.

The floats deployed on this cruise are ROM version 4.33 "parking" floats– they profile as they descend, and adjust their buoyancy by adding or removing oil from the external bladder to maintain the desired depth. The floats used in this program were programmed to complete one cycle every 10 days and were ballasted for 1000 meters.

The floats deployed along 6N in July 1997 are ROM version 4.2 floats, which profile as they ascend and do not have control of their buoyancy while parked. These floats were also ballasted to 1000 meters. At the time of publication, nine of the ten floats deployed were still reporting, and eight of those have good conductivity data.

Due to space limitations on the ship, the floats were brought in from the storage container on deck to the lab in pairs to replace ones that had been deployed. Then the delrin damping collars were installed, and a visual check of the floats was made. We chose to start each float five hours before deployment because that timing allowed completion of the self–test, and deployment with the bladders fully inflated to provide buoyancy, but minimized the time on the surface prior to the initial descent, since the bladder of our floats is programmed to stay full 7.2 hours after the start of the self–test. The plexiglas bladder protector pops off as the bladder fills during the self–test. The floats were all deployed by lowering them gently into the water from the fantail using a slip–line through a hole in the damping collar.

CTD Data Processing :

Seabird's CTD data processing software was used to do initial passes of data conversion, quality control, editing, and storage as flat ascii files. A batch file called process.bat was used to run the following Seasoft programs: datcnv, wildedit, celltm, filter, loopedit, binavg, and split. The code for process.bat is listed in Appendix 2. Raw CTD data were stored on the HBOI acquisition computer in d:\ctd\ in files with the .dat suffix. The processed data files were stored on d:\ctd\proc. The .cnv files contain the filtered data with both down and upcasts. The downcast was extracted and stored in .cdn files while the upcast was stored in .cup files.

Two major adjustments were made during the cruise to the calibration files used to process the data. The first was done after Cast 11, with the secondary conductivity offset modified so that both the salinities were closer (.005) to agreement with the bottle data. These data were edited into SJ9807F.CON using the Seacon program and were used for the

acquisition of casts 12–23. After cast 23, additional analysis was done, suggesting that a better fit was possible. Bottle salinity was regressed to conductivity, and by overplotting this on the CTD conductivity data, a more accurate adjustment was possible. This was applied in SJ9807G.CON before the acquisition of cast 24, and was used on the subsequent casts. All the existing casts were reprocessed using SJ9807G.CON on the raw files.

Additional computations and plots were made using The Mathworks (TM) Matlab software. Ellyn wrote display programs using Paul Robbins' overplotting functions and maps using Rich Pawlowicz's m_map toolbox. Overplots of bottle data on the CTD salinity profiles were generated using plot_salts.m, .mat format versions of the filtered data for each cast and theta–s plots were generated using do_mkcast.m. The final station plots and section contours were also made using Matlab programs Ellyn wrote. The programs used on this cruise were stored on the WHOI analysis PC in c:\users\ellyn\mtl\mfiles.

Data Summary :

All the instrumentation used to collect data during this cruise functioned well, allowing detailed observations of the characteristics of the top 2000 meters of the region sampled. The bottle salinities allowed correction of the conductivity sensor to a high degree of accuracy. Figure 5 shows a plot of the difference between the bottle conductivities at CTD 22, and the data returned by the primary and secondary conductivity sensors.

Theta–salinity (t–s) plots are often used both to assess data quality and to identify water masses. Figure 6a shows full scale t–s plots for stations 1 and 43, the first and last profiles of the cruise, made at the same location, overplotted. Figure 6b shows an enlargement of the deep part of the plot. The similarity between the deep parts of the profiles from the beginning and end of the cruise indicates there was no systematic drift of the CTD during the cruise. The shapes of the t–s plots from the eastern and western extremess of this survey are quite different as shown in figure 7. The western profiles are fairly similar to each other, but the eastern ones are not, suggesting that different water masses were encountered at the three latitudes sampled in the east. Also note that the profile from station 20, on the eastern end of the 16N line, has shallow and deep water properties like the western stations, but the 5 to 7 degree water is more like that of the other eastern profiles.

The features observed in the 11N line were about what the historical data lead one to expect. Warmer surface temperatures were observed in the west, about 1.25 degrees cooler in the east, and the 5 degree water started at about 1000 meters. The sub–surface salinity maximum at ~ 100 meters was pronounced in the western basin. The surface waters are probably fresher than normal in the central part of the section, due the rainy conditions.

The 16N temperature and salinity sections both exhibited much weaker gradients in the

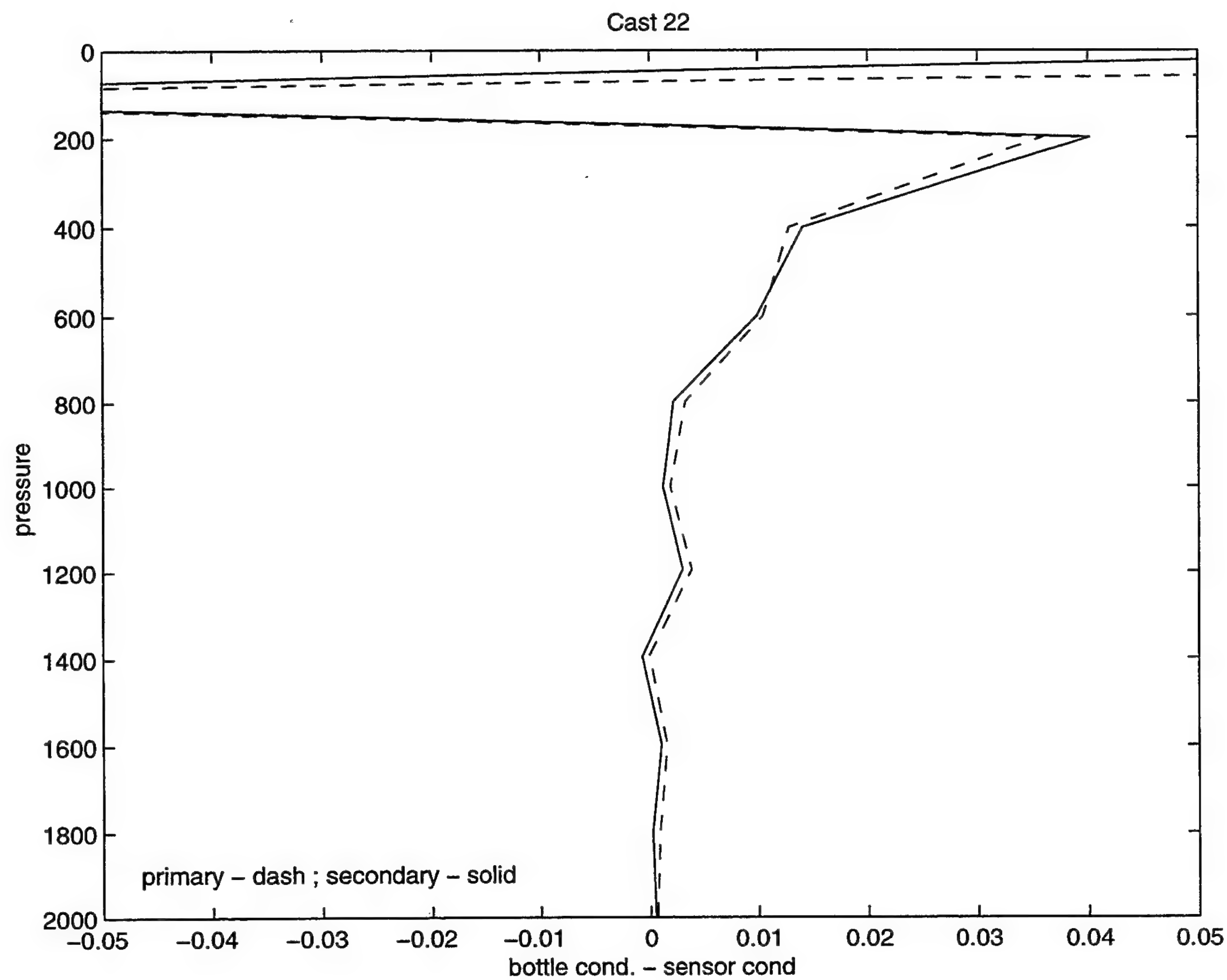

Figure 5. Comparison of the bottle conductivities to each of the two conductivity sensors.

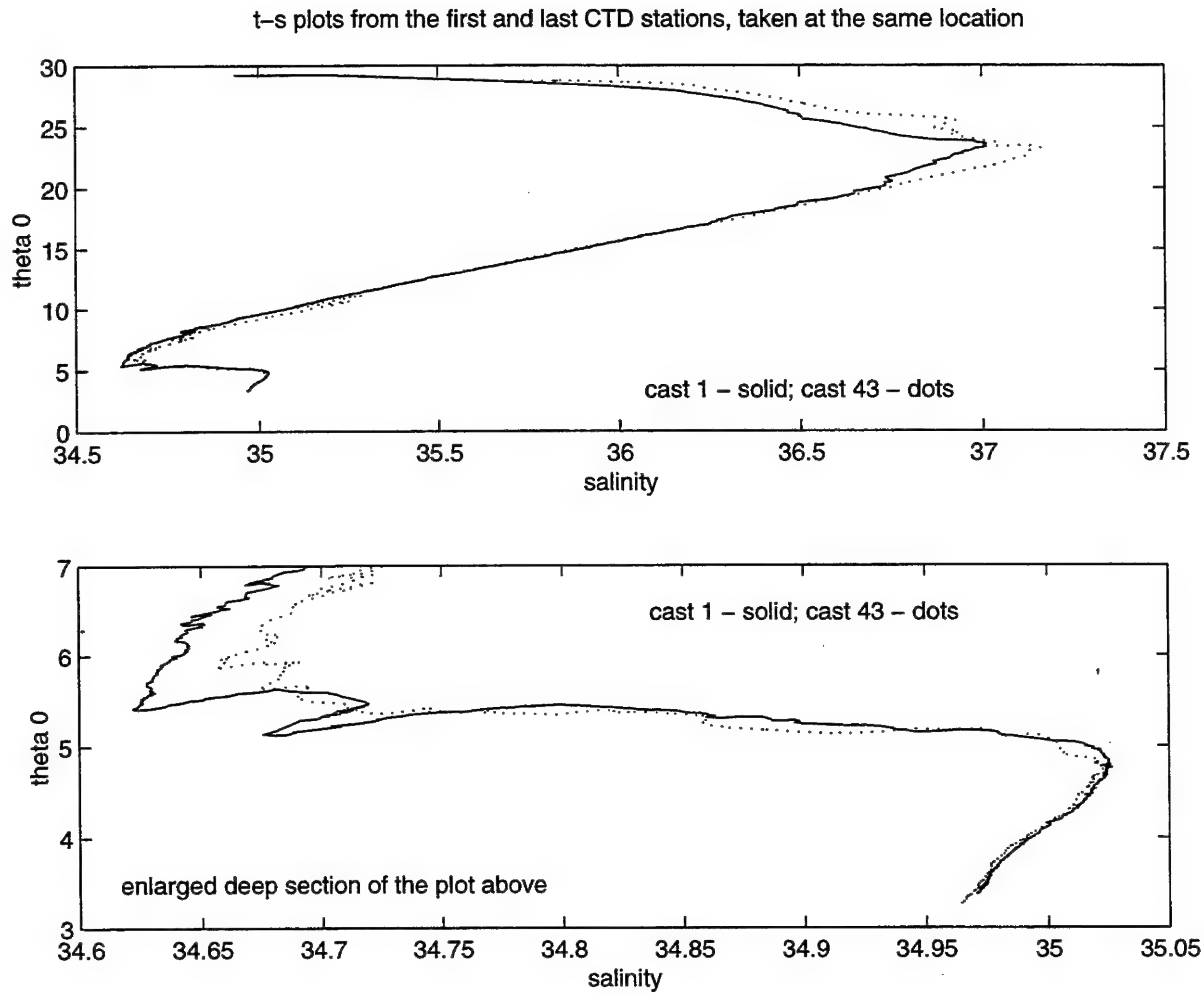

Figure 6a. Full scale theta–salinity plot of profiles 1 and 43.
b. Enlarged deep part of the plot shown in a.

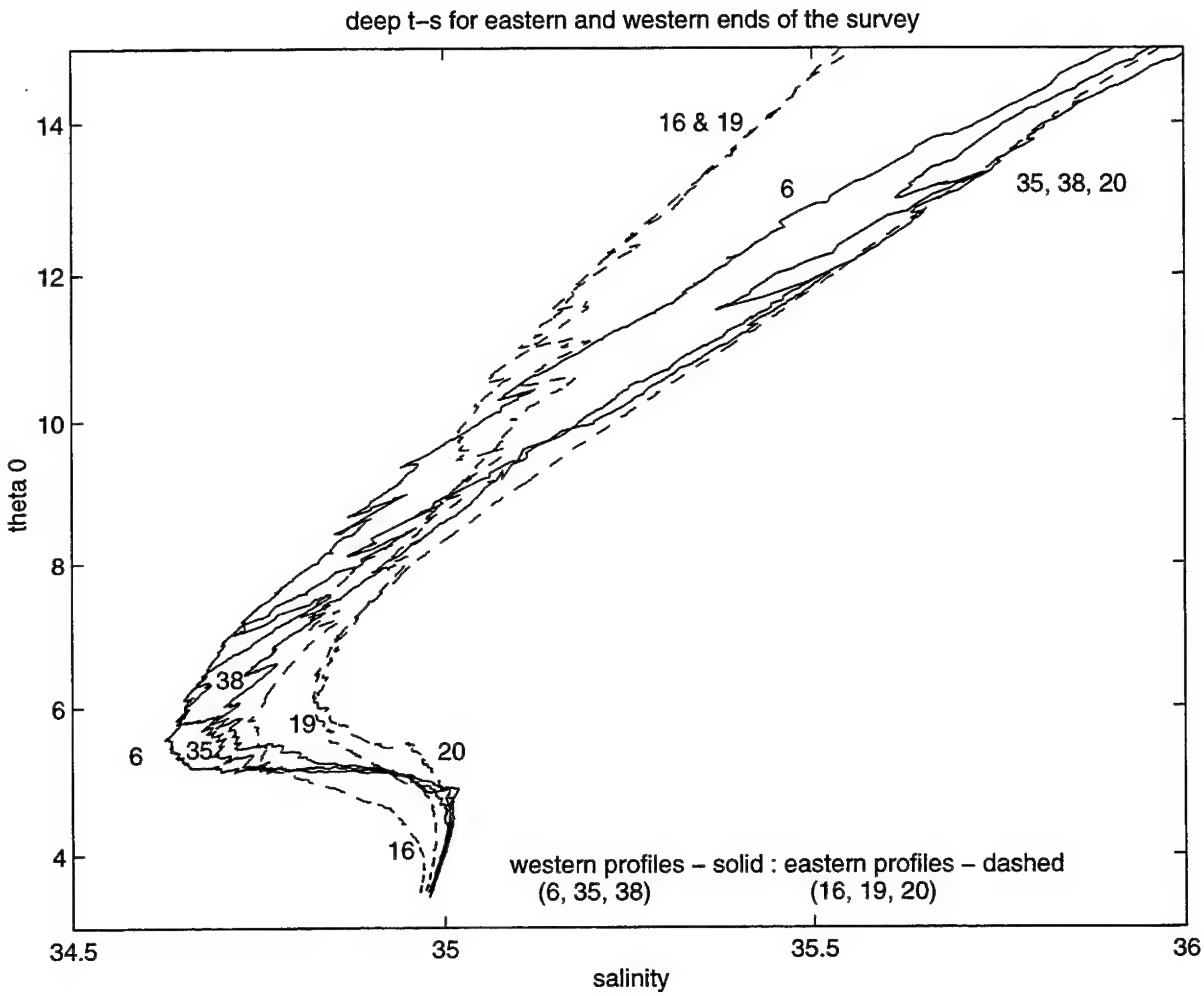

Figure 7. Theta–salinity plots from the east and west ends of the area studied on this cruise.

top 800 meters than those at 11N. The sub–surface salinity maximum is even more pronounced in the western part of the 16N section than it was at 11N. There is also evidence of a front or current between 42W and 45W along 16N that is not present at 11N.

In addition to the data collected for the S–PALACE deployments, well–defined staircase features were observed between 200 and 500 meters on CTD casts 4, 7 and 8, with less well–defined features detectable in stations 2–9 or eastward to 50W. Figure 8 shows the depth range of profiles 4, 7 and 8 with well–defined staircases. On the return trip, there were no stations with as clearly defined staircases as those mentioned above. Several had one or two steps between 500 and 600 meters, but nothing well developed. Cast 35, the furthest west on 13.5N, had a lot of structure between 200 and 600 meters, including inversions, but didn't have staircases. Cast 42 at 14N had similar features, while casts 41 and 43 did not, indicating a non–uniform distribution of these features in this region.

The data from the CTD casts are thought provoking and should provide accurate ground–truth measurements for the data acquired and telemetered in by the floats. By the end of the cruise, the floats deployed along 11N had all made their first reports. At the time of writing this report, all the floats had transmitted data at least 10 times. The data quality of all the temperature profiles is good. One conductivity sensor went bad after the first profile. Several more of the conductivity sensors exhibited episodic offsets of the whole profile, probably due to transient biofouling. We are in the process of trying to find the cause of these shifts and develop a reliable method of correcting them, based on the stability of the deep temperature – salinity relation. All in all, this was a very successful cruise.

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Schmitt, R. W., H. Perkins, J. D. Boyd, and M. C. Stalcup, 1987. C–SALT: An investigation of the thermohaline staircase in the western tropical North Atlantic. *Deep–Sea Research*, 34(10A), 1655–1665.

Acknowledgements :

We gratefully acknowledge the contributions of the officers and crew of the *R/V Seward Johnson*, who coped amiably with rough seas and difficult working conditions during the 11N leg of this trip. We also thank Jim Ledwell for the use of his CTD and associated equipment on this cruise. The Matlab functions supplied by Paul Robbins and Rich Pawlowicz were of great help with the data analysis. We appreciate the generous support of the National Science Foundation in funding this research under grant number OCE–831869.

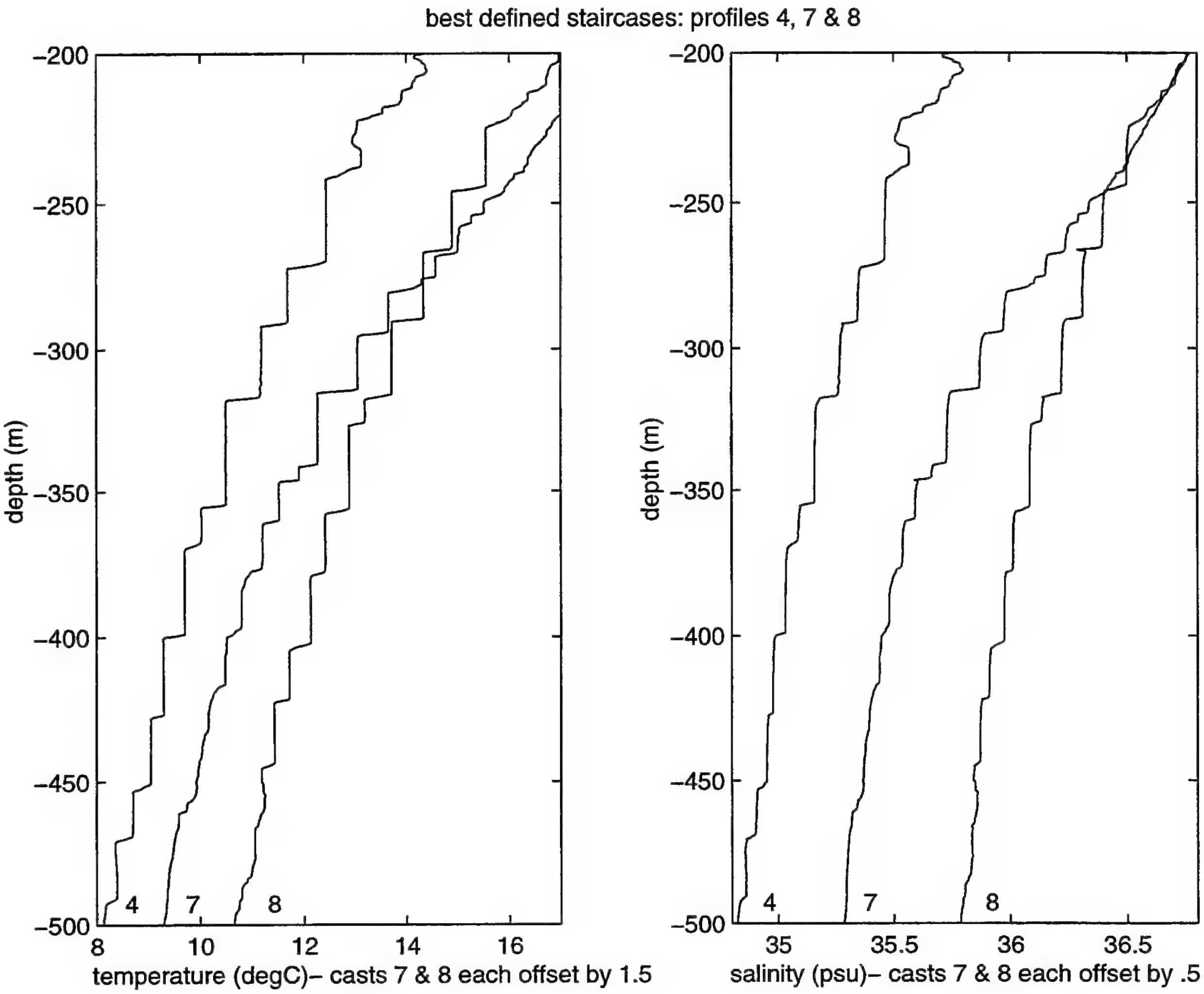

Figure 8. Thermohaline staircase features observed in CTD profiles 4, 7 and 8, obtained southeast of Barbados.

Appendix 1 : Station log

date (1998) Mon. day	time (gmt) hrmn	position latitude deg.	min.	longitude deg.	min.	comments
Oct. 12	1400	13	6.000	59	37.700	Depart Barbodos
Oct. 12	2016	13	30.076	58	48.016	CTD cast 1
Oct. 13	0154	13	0.035	58	19.062	CTD cast 2
Oct. 13	0727	12	29.955	57	50.470	CTD cast 3
Oct. 13	1307	11	59.997	57	21.503	CTD cast 4
Oct. 13	1830	11	30.050	56	52.837	CTD cast 5
Oct. 14	0013	10	59.982	56	23.886	CTD cast 6
Oct. 14	0145	11	0.424	56	24.652	S–PALACE–240 / 29642 deployed
Oct. 14	1255	11	0.102	54	20.886	CTD cast 7
Oct. 14	1425	11	0.353	54	21.096	S–PALACE–200 / 29613 deployed
Oct. 15	0117	11	0.036	52	17.973	CTD cast 8
Oct. 15	0248	11	0.961	52	18.154	S–PALACE–222 / 29638 deployed
Oct. 15	1346	10	59.993	50	15.435	CTD cast 9
Oct. 15	1514	11	0.624	50	16.349	S–PALACE–234 / 29635 deployed
Oct. 16	0346	11	0.023	48	12.753	CTD cast 10
Oct. 16	0518	11	1.200	48	13.500	S–PALACE–213 / 29637 deployed
Oct. 16	1843	11	0.040	46	5.930	CTD cast 11
Oct. 16	2006	11	0.135	46	5.222	S–PALACE–236 / 29639 deployed
Oct. 17	0821	10	59.772	43	59.425	CTD cast 12
Oct. 17	0946	11	0.685	43	59.001	S–PALACE–239 / 29641 deployed
Oct. 18	0727	11	0.050	39	58.668	CTD cast 13
Oct. 18	0855	11	0.749	39	59.721	S–PALACE–238 / 29640 deployed
Oct. 19	0804	11	0.125	35	58.605	CTD cast 14
Oct. 19	0937	11	1.622	35	58.594	S–PALACE–220 / 29621 deployed
Oct. 20	0817	10	59.957	31	58.738	CTD cast 15
Oct. 20	0943	11	0 612	31	57.413	S–PALACE–214 / 29615 deployed
Oct. 21	0219	11	0.092	28	45.002	CTD cast 16
Oct. 21	0348	11	0.010	28	46.258	S–PALACE–237 / 29628 deployed
Oct. 22	0346	11	0.028	24	20.012	CTD cast 17
Oct. 22	0518	11	0.563	24	19.558	S–PALACE–225 / 29625 deployed
Oct. 23	0400	10	59.987	19	54.955	CTD cast 18
Oct. 23	0626	10	59.657	19	55.090	S–PALACE–229 / 29630 deployed
Oct. 25	0346	13	29.987	28	44.987	CTD cast 19
Oct. 25	0514	13	29.724	28	48.924	S–PALACE–226 / 29626 deployed
Oct. 25	1909	16	0.145	28	44.952	CTD cast 20
Oct. 25	2033	16	0.985	28	45.204	S–PALACE–230 / 29631 deployed
Oct. 26	1259	16	0.003	31	58.807	CTD cast 21

Oct. 26	1427	16	0.461	31	59.521	S–PALACE–218 / 29619 deployed
Oct. 27	0344	13	29.928	31	58.703	CTD cast 22
Oct. 27	0513	13	30.380	31	59.520	S–PALACE–224 / 29624 deployed
Oct. 28	0055	13	30.078	35	58.500	CTD cast 23
Oct. 28	0228	13	30.851	35	59.560	S–PALACE–221 / 29622 deployed
Oct. 28	1606	15	59.982	35	58.642	CTD cast 24
Oct. 28	1732	15	59.990	35	59.260	S–PALACE–235 / 29636 deployed
Oct. 29	1010	15	59.957	39	58.960	CTD cast 25
Oct. 29	1403	16	0.554	40	0.337	S–PALACE–232 / 29633 deployed
Oct. 30	0908	15	59.978	43	59.742	CTD cast 26
Oct. 30	1032	16	0.828	43	59.807	S–PALACE–227 / 29627 deployed
Oct. 30	1535	15	59.968	45	0.198	CTD cast 27
Oct. 30	1705	16	0.772	45	1.022	P.Vertes float 174 deployed
Oct. 30	2221	15	59.945	46	6.043	CTD cast 28
Oct. 30	2348	16	0.719	46	6.665	S–PALACE–219 / 29620 deployed
Oct. 31	1010	15	59.913	48	12.683	CTD cast 29
Oct. 31	1133	16	0.351	48	12.375	S–PALACE–212 / 29614 deployed
Oct. 31	2133	16	0.047	50	15.400	CTD cast 30
Oct. 31	2300	16	1.029	50	15.390	S–PALACE–217 / 29618 deployed
Oct. 31	2300	16	1.029	50	15.390	P.Vertes float 195 deployed
Nov. 1	0907	15	59.992	52	17.832	CTD cast 31
Nov. 1	1025	16	0.530	52	17.563	S–PALACE–216 / 29617 deployed
Nov. 2	0053	13	29.962	51	13.186	CTD cast 32
Nov. 2	0218	13	30.863	51	13.397	S–PALACE–215 / 29616 deployed
Nov. 2	1217	13	30.100	53	18.040	CTD cast 33
Nov. 2	1347	13	31.092	53	18.756	S–PALACE–233 / 29634 deployed
Nov. 2	1850	13	29.978	54	21.090	CTD cast 34
Nov. 3	0125	13	30.143	55	22.755	CTD cast 35
Nov. 3	0252	13	31.189	55	23.142	S–PALACE–231 / 29632 deployed
Nov. 3	0959	14	45.020	54	51.770	CTD cast 36
Nov. 3	1830	15	59.908	54	20.920	CTD cast 37
Nov. 3	2029	16	0.877	54	20.803	S–PALACE–228 / 29629 deployed
Nov. 4	0632	15	59.998	56	24.020	CTD cast 38
Nov. 4	0759	16	0.424	56	24.428	S–PALACE–223 / 29623 deployed
Nov. 4	1139	15	29.952	56	52.843	CTD cast 39
Nov. 4	1644	14	59.965	57	21.573	CTD cast 40
Nov. 4	2136	14	29.877	57	50.340	CTD cast 41
Nov. 5	0229	13	59.975	58	19.187	CTD cast 42
Nov. 5	0729	13	29.953	58	48.063	CTD cast 43
Nov. 5	1050	13	06.530	59	38.253	Arrive Barbados

Appendix 2: PROCESS.BAT

```
rem  file: process.bat
rem  date: 6 April 1998
rem  auth: J. Doutt

rem  takes a single SEABIRD cast and runs the chain of processing programs
rem   run as follows: process cast12

rem   note: this file, 'PROCESS.BAT', lives 1 directory down from the data
rem        and should be run from the "process.bat' directory

rem  After "SPLIT" the downgoing & upgoing casts are respectively in
rem        "fname.cdn"  and "fname.cup"

rem   RVSJ configuration [ mods : etm 10/98 ]
rem    have to run the software from u:

c:
cd \seasave

  datcnv -ij:\ctd\%1 -cj:\ctd\%2 -oj:\ctd\proc\%1
   if errorlevel 1 goto abort

  wildedit -ij:\ctd\proc\%1 -oj:\ctd\proc\%1
   if errorlevel 1 goto abort
rem  goto end

  celltm -ij:\ctd\proc\%1 -oj:\ctd\proc\%1
   if errorlevel 1 goto abort

 filter -ij:\ctd\proc\%1 -oj:\ctd\proc\%1
   if errorlevel 1 goto abort

 loopedit -ij:\ctd\proc\%1 -oj:\ctd\proc\%1
   if errorlevel 1 goto abort

 binavg -ij:\ctd\proc\%1 -oj:\ctd\proc\%1
   if errorlevel 1 goto abort

  split -nd -ij:\ctd\proc\%1 -oddown -ouup
     j:
     cd \ctd\proc
     rename down.cnv %1.cdn
     rename up.cnv %1.cup
   if errorlevel 1 goto abort

 goto end

 :abort
   echo  batch process interrupted by user

 :end

 j:
```

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16. Abstract (Limit: 200 words)

R/V *Seward Johnson* cruise 98-07 occurred between October 12 and November 5, 1998. The goal of the cruise was to deploy 30 Salinity Profiling Autonomous Lagrangian Current Explorer (S-PALACE) floats in the tropical Atlantic as part of the Atlantic Circulation and Climate Experiment (ACCE). These floats are neutrally buoyant and drift with the water in which they are deployed. They are programmed to obtain temperature and salinity profiles of the top 1000 meters of the ocean every ten days. To ascertain the validity of the float data, a CTD profile was made at the site and time of the deployment of each float.

The data from these floats augments data already being obtained from ten floats deployed last year. Given 40 floats in the tropical North Atlantic, reporting every 10 or 14 days with an expected operational life of 3-5 years, we hope to gather 5000 to 7000 profiles from these floats in the coming years. The temperature and salinity profiles, along with derived properties will aid in examining the mechanisms of upper ocean heat and freshwater storage. This data should also be useful in climate and weather prediction models.

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neutrally buoyant floats
tropical circulation
salinity profiling ALACE

b. Identifiers/Open-Ended Terms

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